Antenna at Grimeton, Sweden, radio station SAQ (Courtesy: The Alexander Association http://alexander.n.se/?lang=en)

Electrical Pioneers:

The Life and Times of Guglielmo Marconi (1874-1937) and Ernst Alexanderson (1878-1975)

By Georg Wiessala

Steampunk, Shock and Awe

I have just re-read "The First Men in the Moon," the famous novel by H.G. Wells. It is a great piece of scientific romance, steam-punk, which harks back to Jules Verne and other early sci-fi authors. What I did not appreciate during earlier readings, is just how much Wells was fascinated by the radio discoveries of the day. 'Radiant energy,' Wells has one of his heroes speculate, 'was anything like light or heat or those Röntgen rays there was so much talk about a year or so ago, or the electric waves of Marconi, or gravitation.' Tesla gets a look in too, when Wells mentions possible communications from the Moon (Wells, 2017: 12 [quote] and 165 [Tesla])

It is hard to imagine in our own age just how groundbreaking, confusing and inspirational the work of the early radio pioneers was in theirs, at a time when even the Eiffel Tower became a radio mast. However, our era of borderless communication and technological advance carries with it echoes of the 'globalization' of earlier times, as the 19th Century turned into the 20th. In the history of radio, there are at least three key themes a time-traveller looking at our 21st Century from the vantage point of, say, 1890, would easily recognize.

First, if you give people limitless communication, this changes everything, from economic to international relations, from crime to politics. As Dr. Hawley Harvey Crippen was apprehended in the first manhunt that made use of Marconi technology, so, in our time, social media are both the bane of terrorists and the lifeblood of their vicious propaganda. The Crippen story, by the way, is subject of Erik Larson's brilliant 2006 novel, Thunderstruck.

Second, the use of electromagnetic waves and every subsequent technology based in it inspires awe and greed, philanthropy and superstition in equal measure. Worried as we are about the rise of the machines, unaccountable algorithms and artificial intelligence today, an observer of the age of Alexanderson, Marconi, Tesla and Edison would have been similarly concerned, focusing, instead of that mysterious force from the ether, electricity, invisible 'waves' and new-fangled machines doing the jobs of humans.

Third, in the same way we speak of 'circuits' in electri-

cal engineering, there are many circuitous – and few straight, linear – developments in this early age of wireless. Professor Jim Al-Khalili's recent Open University/ BBC FOUR collaborations on Shock and Awe – The Story of Electricity was a great reminder of this, showing how the time of the electrical pioneers connects to ours though time. **www.bbc.co.uk/programmes/p00kjq6d www.open.edu/openlearn/tv-radio-events/tv/shock-awe/shock-and-awe-the-story-electricity**

On the Shoulders of Giants

Then as now, new technologies and discoveries were made by those who stood on the shoulders of giants. Table 1 shows a rough time-line of just some of the key minds in this area, sorted by date of birth and with apologies for any glaring omissions and simplifications:

Table 1: Some Electrical Pioneers

Benjamin Franklin (1706-1790) Positive and Negative Electric Charge
Alessandro Volta (1745-1827) Electric Battery (Voltaic Pile)
Hans Christian Ørsted (1777-1851) Electromagnetism
Michael Faraday (1791-1867) Mutual Induction, Electric Motor, Magnetic Field
Heinrich Rühmkorff (1803-1877) Induction Coils
Heinrich Geissler (1814-1879) Gas Discharge Tube
Mahlon Loomis (1826-1886) Aerial Telegraph (Radio Transmission)
James Clerk Maxwell (1831-1879) Theory of Radio Waves
Édouart Branly (1844-1940) Radio Conductor/ Coherer
Oliver Lodge (1851-1940) Electromagnetic Waves
Joseph John Thomson (1856-1940) Electron
Nikola Tesla (1856-1943) AC Motor, Tesla Coil, Radio Transmission
Heinrich Hertz (1857-1894) Radio Transmission
Jagadish Chandra Bose (1858-1937) Microwave Radiation, Semiconductors, Crystal Detector
Alexander Popov (1859-1906) Radio Transmission
Reginald Fessenden (1866-1932) Radio, voice transmission, sonar
Guglielmo Marconi (1874-1937) Radio Transmission
Ernst Alexanderson (1878-1975) Alexanderson Alternator/ VLF Transmitter

The discovery of the electromagnetic field, crystals, the cable telegraph, wireless telegraphy, valves, 'cathode rays,' semiconductors, transistors, electrons, the Earth's very own electrical phenomena, and much more besides, was, it would seem, attributable not to individuals but to innovative chains of discoverers and scientists. Some, such as Hertz, Bose, Lodge and Tesla, may not have been commercial geniuses; others, such as Marconi and Westinghouse were much more finely-attuned to patenting their technologies and putting them to practical use. Ernst Alexanderson, in this respect, seems to have been more like Tesla than Marconi.

Therefore, many different individuals contributed the

The Alexanderson transmitter set consists of three parts: the driving motor, a gear drive and the high frequency generator, commonly called the alternator. They are assembled on a solid base of steel. The weight of the complete transmitter set is about 50 tons. (Screen shot from a YouTube video of the transmitter courtesy: The Alexander Association. http://alexander.n.se/the-radio-station-saq-grimeton/the-alexanderson-transmitter/?lang=en)

innovations needed to create broadcast radio and TV. Mahon (2004: 180) summarises that, "in the popular account, Marconi gets the credit for inventing radio, and Hertz for discovering the waves. Maxwell, whose inspired prediction started the whole thing off, is rarely mentioned." Last but by no means least, note the temporal frame within which they all lived – a space of a mere 250 years for an entire electrical revolution. Was there something in the ether from the 1700s onwards? In this article, I would like to dwell on the two last names on the list, Marconi and Anderson, one very well-known, one, perhaps, as lesser-known radio personality, unless you are seriously into VLF monitoring. This article continues what I began with Nikola Tesla and Kristian Birkeland a few months ago.

A Rare Catch: SAQ Grimeton

SAQ Grimeton on 17.2 kHz is unique. It is said to be the last transmitter left in the world generating RF power without any electronic parts. No tubes, no semiconductors, transistors, no nothing; only an engine driving an AC generator. The vintage alternator is running at high speeds, emitting up to 200 kW and the entire apparatus can generate frequencies from around 14 to 40 kHz, with 14.5 to 17.4 kHz the most interesting ones. Automated, dependable, machine transmitters like this were used from the beginning of the 20th Century to establish an early global www of communications and to communicate across oceans.

Between roughly 1860 and 1930 many unemployed Swedes emigrated to the US and the radio station, built in 1924, became a lifeline to the home country. Subsequently, the transmitter was put into service to communicate with submarines on VLF. It was eventually decommissioned in 1995. However, the alternator is open to the public via the local tourist office (at Varberg). SAQ Grimeton became a

World Heritage Site in 2004 and is attracting its own dedicated community of followers, much like the Marconi sites at Poldhu and Porthcurno in Cornwall and at the Villa Griffone, near Bologna in Italy. **http://whc.unesco.org/en/list/1134**

At Grimeton, six 400 feet high towers, with 150-foot cross-arms supports, carry a multi-wire antenna for SAQ. The actual A-1 mode Morse code signal radiates from vertical wires, one from each of the towers. The station can easily be heard in Europe and the US. SAQ traditionally transmits at Christmas and on Alexanderson Day (1 July) and on some other occasions such as World Radio Day (13 February).

Many individuals and amateur radio associations around the globe get in on the action, with monitoring, special call signs and events. The Grimeton site's amateur radio station is SK6SAQ. Receiving it is easy, using a VLF receiver/converter/SDR and software. **www.nsarc.ca/hf/saq.pdf www.vlf.it/parmigiani/saq_eng.htm**

Ernst Alexanderson: Alternators and Continuous Waves

The behemoth in Sweden is a remarkable feat of engineering. It was developed by the Swedish engineer and radio pioneer, Ernst F. W. Alexanderson, who worked for General Electric New York and was later chief engineer at the Radio Corporation of America (RCA). Alexanderson was directly influenced by Charles P Steinmetz (1865-1923) and Reginald Fessenden (1866-1932). This multi-lingual Swede is, perhaps, not as well-known as Marconi or Edison, probably because he worked for others, General Electric (from 1901) and its subsidiary, the Radio Corporation of America (from 1952). Consequently, many of his 344 patents were owned by his employers.

Notwithstanding this, Alexanderson's work was ground-breaking. The high-frequency alternators he designed for use in radio succeeded the earlier spark and arc transmitters, which had used Morse code dots and dashes for telegraphy. An alternator is a device that converts direct into alternating current. The one installed in Brunswick, New Jersey, in 1917 facilitated transatlantic radio communication during the First World War, most famously President Woodrow Wilson's messages to forces near the end of the war. Other alternators, like the Swedish machine, helped the home country to stay in touch with the Swedish diaspora across the Pond.

In 1921, Einstein toured the New Brunswick facility and was impressed, expressing "great surprise and interest at the high perfection" of American radio development. Professor Einstein was asked to send a message to Nauen, Germany. A newspaper later wrote, "He did and in exactly six minutes received the following reply: 'Many thanks and reciprocations. Most hearty greetings to the great German scientist. Officer in charge POZ.'" **tinyurl.com/y7kwck5v**

Alexanderson's high-frequency alternators were so revolutionary because they enabled operators to transmit radio as a continuous wave ('undamped'). This made the broadcasting of voice, pictures and music possible for the first time, undoubtedly giving the USA a significant early start in radio communications innovation. Arguably, Alexanderson is best known for his work on television. However, he also experimented with shortwave radio propagation and invented electrodynamic amplifiers and radar altimeters (before the development of radar).

Alexanderson sent the world's first radio facsimile messages from 1924-26 and demonstrated home television reception at 48 lines and 16 frames in Schenectady, New York, as early as 1927/28. It appears that he (not unlike Tesla) also predicted wireless transmission of electricity through the air. Not surprising then, that he was (posthumously) admitted to the National Inventors Hall of Fame in Arlington, Virginia, in 1983.

Guglielmo Marconi: Magic Boxes and Public Engagement

It seems that Marconi understood very well the significance of the audio quality produced by Alexanderson's alternator; so much so that he tried a few times to purchase the exclusive rights of use to the technology from GE. As Wenaas (2007: 23) points out, GE was about to grant Marconi sole rights to Alexanderson's machine, which, remember was the key transoceanic communications technology at the time. However, the US Navy convinced GE to create a wireless communications company as an alternative market for the alternator.

This story is one of many that make up the anecdotal evidence about Marconi's life. There are others. For example, the incongruously-named German Professor Adolphus Slaby witnessed Marconi's success in transmitting across the Bristol Channel and hurried back to Germany to tell Kaiser Wilhelm II about this. Weightman notes (2004: 29), "and so it was that Marconi's first benefactor, William Preece, had unwittingly enabled the nation which was for many years be a bitter rival of Britain in the development of wireless telegraphy to indulge in a blatant piece of industrial espionage."

Moreover, in 1902, the American Institute of Electrical Engineers (founded in 1884) held a dinner in Marconi's honour at the Waldorf Astoria – the very hotel in which Nikola Tesla resided at the time. In one of the most famous 'near-misses' in history, Tesla did not turn up, sending a token message. In 1903, a public demonstration by Guglielmo Marconi of his Morse code radio system was hijacked by rogue protest transmissions by the moustachioed British music-hall-magician Nevil Maskelyne, embarrassing Marconi by proving that his system was less than secure (Marks, 2011). Meanwhile Arthur Conan Doyle, the leading 'spiritualist' of the day and creator of Sherlock Holmes, wrote to Marconi to let him know that the new medium of wireless telegraphy would be well-suited to the investigation of psychic phenomena (Raboy, 2016: 476). Conan Doyle famously set his Sherlock Holmes short story The Adventure of the Devil's Foot near the Cornwall Marconi sites, in a small cottage, near Poldhu Bay (Weightman, 2003; 72). In 1910,

Marconi's wireless system was used to penetrate the disguise of Dr Hawley Harvey Crippen and his companion Miss Ethel Le Neve aboard the transatlantic liner in which they were escaping to America after the murder of Mrs Crippen in London. Four years later, Marconi narrowly missed travelling on the Titanic during her maiden voyage, having joined an earlier ship to America. Those who were saved on the Titanic survived because of wireless, which was used to raise the alert. Stories like this abound in Marconi lore.

But where exactly can we find the real Marconi? First, consider his strategies. Helped by an English relative and becoming a protégé of Sir William Henry Preece (1834-1913), the then chief engineer of the British Post Office, Marconi gave away little, took out patents, conducted research and founded a range of companies such as Marconi Cable and Wireless. Second, Marconi was visible. Aware of the power of hands-on public engagement, the Italian relentlessly demonstrated his wireless equipment. From his earliest appearances in Toynbee Hall (London, 1896) and Madison Square Garden (1898) to the AIEE dinner in 1902 (above), via his coverage of the America's Cup race in New York in 1899, he rarely wasted an opportunity to promote his work to financiers and backers. Apart from commercial success, his efforts earned him the Nobel Prize in 1909, jointly with Ferdinand Braun (the German co-inventor of the cathode ray tube and of semiconductors).

Third, Marconi was also public. He bridged the Bristol Channel, sending a signal between Lavernock Point and Flat Holm island in 1897. He publicly transmitted to Queen Victoria on the Isle of Wight and sent signals across the English Channel in 1899. In 1901, he famously transmitted the letter 'S' across the Atlantic from Poldhu (Cornwall) to Newfoundland. Cheney points out (2001: 201) that, for this, Marconi utilised Tesla's radio patent (No. 645,576), filed in 1897 and issued in March 1900. At Madison Square Gardens in 1898, Marconi used a Tesla oscillator (without any acknowledgement) to show how mines could be blown up by firing a 'Cuban dynamite gun' via telegraphy (Cheney, 2001: 163). Tesla labelled this the 'Borgia-Medici' method of science. And the argument over who really invented radio continues, of course, unabated (good overview: Andersen, 1980).

Fourth, there were always the courts. The litigation between Tesla and Marconi from 1915 onwards has echoes of the War of the Currents involving Thomas Alva Edison and George Westinghouse in the late 1880s (Hughes, 1983: 106/7, 120-135; Carlson, 2015: 377). These battles have become part of radio history, as has the US Supreme Court's finding in Marconi Wireless Telegraph Company of America versus United States, of 21 June 1943. The verdict, by the way, vindicated Tesla and his fundamental radio patent.

Further Reading

Alexanderson, E.W.F. (1920): Transoceanic Radio Communication, **http://earlyradiohistory.us/1920alt.htm**

Electrical engineer/inventor Guglielmo Marconi with the spark-gap transmitter (right) and coherer receiver (left) he used in some of his first long distance radiotelegraphy transmissions during the 1890s. (By Published on LIFE [Public domain or Public domain], via Wikimedia Commons)

Andersen, L. I. (1980): Priority in the Invention of Radio: Tesla vs. Marconi (Antique Wireless Association Monograph No. 4, March 1980)

Carlson, W.B. (2015): Tesla: Inventor of the Electrical Age

Cheney, M. (2001) Tesla – Man Out of Time

Hughes, T.P. (1983) Networks of Power Mahon, B. (2004):

The Man Who Changed Everything – The Life of James Clerk Maxwell

Malanowski, G. (2011) The Race for Wireless – How Radio was Invented (or Discovered)

Marks, P. (2011) Dot-Dash-Diss: The Gentleman Hacker's 1903 'lulz' (New Scientist, December 20th)

Raboy, M. (2016): Marconi – The Man Who Networked the World

Sikö, A. (2013) Listening to Grimeton **http://grimeton.org/wp-content/uploads/2016/04/Listening-to-Grimeton.pdf**

Sungook Hong (2001) Wireless (pdf: **https://monoskop.org/images/f/f4/Hong_Sungook_Wireless_From_Marconis_Black-Box_to_the_Audion.pdf**)

Telenius-Lowe, S. (2017): Pioneers of Radio – A Timeline, in: Practical Wireless, March 2017: 46-50

Wenaas, E.P. (2007) Radiola – The Golden Age of RCA, 1919-1929

Weightman, G. (2004): Signor Marconi's Magic Box

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